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Constraints on diffuse high energy neutrino flux from Star-forming Galaxies

If star-forming galaxies could accelerate cosmic ray to very high energies, high energy neutrinos and gamma-ray photons will be produced during cosmic ray propagation. Considering the gamma-ray point sources below the detection threshold, the source count distribution above 50 GeV places an upper limit on non-blazar component of the EGB measured by Fermi-LAT. Keith Bechtol et al. found a strong tension between the upper limit and the models that considering star-forming galaxies as the dominant sources of diffuse neutrino flux observed by IceCube.

In our work, we use the direct measurement of gamma-ray optical depth due to EBL to reduce the model dependent uncertainties brought by EBL model in Keith Bechtol et al 2017. We study on two neutrino emission spectra: single power law with exponential cutoff and broken power law with exponential cutoff. For single power law $dN/dE \propto E^{-\gamma}$, the upper limit of neutrino flux at 100 TeV is compatible with 95.4% confidence region of the best fit parameter(assuming a single power law) to through-going track events but is lower than the 68.3% confidence region. For broken power law, we choose the same broken energy(25 TeV) in Keith Bechtol et al 2017 and test the spectral index γ_1 of lower energy band from 2.0 to 2.7. We find that the upper limit of neutrino flux at 100 TeV will be lower than the 95.4% confidence region of the best fit parameter if $\gamma_1 > 2.2$. We also try a new broken energy at 120 TeV. Such a sensitivity to low energy spectral index, however, does not change too much.

According to our work, the possibility that star-forming galaxies are dominant sources of diffuse neutrino flux can not be excluded, if we don't have a preference on the best fit parameters to different data sets. If there is softening above a certain energy around 10 to 100 TeV in neutrino spectrum, we have to get a very hard spectrum below such energy in the cosmic ray acceleration and neutrino production models.

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